PATENT SPECIFICATION

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COMPLETE SPECIFICATION

NO DRAWINGS

Alloys Having Improved Machinability

We, THE CARPENTER STEEL COMPANY, a corporation organised under the laws of the State of New Jersey, United States of America, of Reading, State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the provision of alloys having improved machinability.

Machinability may be defined as that property of an alloy which governs the performance of the alloy machining processes and denotes the success with which a material may be machined. Metal machinability is a complex and not fully understood property. However, the manifestations thereof are readily recognized by a skilled artisan from the manner in which the alloy is machined by cutting tools in such operations as turning, milling, broaching, threading, reaming, sawing or grinding. Free machining alloys are characterized, among other things, by the relatively lower degree of friction or gumminess and hence freer cutting action by the tool; by the small chips removed from the work, and the manner by which the chips fall free from and do not adhere to the tool. Of the many factors which affect machinability, the composition of the alloy appears to be the most significant because of its effect upon the structure, processing, and mechanical properties of the alloy.

Metallurgists have long sought to improve machinability of alloys by modifying their composition or form. For example, for the purpose of improving machinability, varying amounts of one or more of such elements as carbon, phosphorus, sulphur, lead, selenium, tellurium, arsenic, zironium and bismuth have been included in alloys. Sulphur, selenium, tellurium and others of these elements are believed to affect machinability when present in the form of a sulphide, selenide or telluride, respectively, and for this reason one or more of the elements aluminium, chromium, manganese and molybdenum may be included to form such compounds.

The free machining additives hitherto used have had relatively limited usefulness for various reasons. Those compositions in which one or more of the foregoing additives have been utilized with success to provide improved machinability were the result of extended and costly experimentation because, among other things, the proportions of the various alloying elements must be carefully balanced and controlled if other important properties of the alloy are not to be affected or if properties are not to be imparted to the alloy which seriously affect its usefulness. For example, in the case of stainless steel such as that commonly designated as 18-8 stainless, the addition of 0.3% sulphur results in a marked reduction in the corrosion resistance of the composition although a substantial improvement in free machinability is achieved.

The present invention stems from our finding that boron mononitride (BN) dispersed in the matrix of an alloy, particularly one which is machinable if at all only with difficulty, markedly improved its machinability. This improved free machinability is obtained without objectionably affecting other desired properties of the composition. The beneficial dispersion of boron mononitride is readily obtained in accordance with the present invention in both ferrous and nonferrous alloys. Compositions containing one or more of the elements iron, nickel, cobalt or chromium as

Example 27 exemplifies martensitic stainless steel alloys of the present invention which among other things may be utilized when the effects of high temperature must be withstood. Such alloys comprise in the approximate amounts indicated:

Carbon	.03% to 1.5%
Chromium	4% to 18%
Silicon	Up to 3%
Manganese	Up to 2%
Boron Mononitride	.01% to 1%

In addition there may be included varying amounts of other elements, including up to 2.5% nickel; the remainder being substantially iron. Molybdenum, zirconium, phosphorus, sulphur and selenium may also be included for their effect upon machinability.

The alloys of Examples 26 and 27 were prepared as was described in connection with Examples 3-12 of Table I. The alloy of Example 26 is identified as A.I.S.I. type No. 410 and contains no boron mononitride. When tested for machinability the specimen of this alloy gave an average value of .158. The alloy of Example 27 has a composition comparable in all respects to that of Example 26 but contains .16% boron mononitride. The specimen of Example 27 was found to have a free machinability value of .266.

Examples 29 and 31 exemplify high temperature, heat resistant alloys of the present invention which comprise in the approximate amounts indicated:

Carbon	Up to .3%
Manganese	Up to 3%
Silicon	Up to 2%
Chromium	Up to 30%
Boron Mononitride	.01% to 1%

Varying amounts of other elements are usually included such as molybdenum and tungsten together or alone in total amounts up to 15%, up to 10% columbium, and titanium and aluminum each in amounts up to 10% but with the combined total of titanium and aluminum no more than 15%. Depending upon whether a particular alloy is to have an iron, nickel or cobalt base, it may contain up to about 80% nickel and/or cobalt with the remainder substantially iron.

The alloys of Examples 28-31 were prepared as was described in connection with the alloys of Table I except that Examples 28 and 29 were heat treated for 8 hours at 2050° to 2075°F., and Examples 30 and 31 were heated for 4 hours at 2000°F., water quenched followed by machining and testing.

In the alloy of Example 29, the relatively small amount of boron mononitride formed is attributed to the presence of the titanium which acts to tie up nitrogen and boron. Thus, as has been pointed out hereinabove, better results are attained with this alloy when the boron mononitride as such is added to the molten alloy. Nevertheless, it is to be noted that with only .02% boron mononitride the free machinability of Example 29 is markedly improved over that of Example 28 which does not contain boron mononitride.

The free machinability of the alloy of Example 31, with a boron mononitride content of .05% is improved to a value of .290 as compared to the value of .067 obtained with the specimen of the comparable alloy of Example 30 which contained no boron mononitride.

WHAT WE CLAIM IS:—

1. A process for making steels or nickel and/or cobalt and/or chromium base alloys having improved machinability which comprises dispersing in the alloy matrix 0.01% to 1% and preferably 0.01 to 0.5% boron mononitride.

2. A process according to claim 1, in which preformed solid boron mononitride is added in the desired amount to the molten alloy constituents.

3. A process according to claim 1, in which boron and nitrogen are added to the molten alloy constituents in uncombined form, whereafter the alloy is cast as a solid body and the latter is heated at a temperature of 1700°F., to 2300°F., until the desired amount of boron mononitride is formed *in situ*.

4. A process according to Claim 1 for making alloys having improved machinability substantially as hereinbefore described.

5. Alloys having improved machinability whenever produced by the process according to any one of the preceding claims.

6. An austenitic stainless steel having improved machinability produced by the process according to any one of claims 1 to 4 and containing .01% to 1% boron mononitride, 0 to .25% carbon, 0 to 8% manganese, 0 to 3% silicon, 0 to 26% chromium, 6% to 46% nickel, the remainder being iron except for incidental impurities.

7. An austenitic stainless steel according to claim 6, including at least one of the elements columbium, titanium, molybdenum, copper, sulphur, phosphorus, selenium, lead, tellurium, arsenic, zirconium and bismuth in an amount up to 3%.

8. An alloy steel having improved machinability produced by the process according to any one of claims 1 to 4 and containing .01% to 1% boron mononitride, 0 to 2.5% carbon, .10% to 3% manganese, .10% to 3% silicon, 0 to 18% chromium, 0 to 8% vanadium, 0 to 10% molybdenum, 0 to 20% tungsten, the remainder being iron except for incidental impurities.

9. An alloy steel according to claim 8 including 0 to 12% cobalt, 0 to 3.5% nickel, 0 to 5% copper and 0 to .25% sulphur.

10. An alloy steel having improved machinability produced by the process according to any one of claims 1 to 4 and containing .01% to 1% boron mononitride, 0 to .35% carbon, 10% to 30% chromium, 0 to 3% silicon, 0 to 1% manganese, the remainder being iron except for incidental impurities.

11. An alloy steel according to claim 11 including 0 to 4.5% aluminium, 0 to .5% titanium, 0 to 5% molybdenum and 0 to 1.5% copper.

12. An alloy steel according to claim 10 or 11 including at least one of the elements phosphorus, sulphur, selenium, lead, tellurium, arsenic, zirconium and bismuth in an amount conventional for promoting easy machinability.

13. A martensitic stainless steel having improved machinability produced by the process according to any one of claims 1 to 4 and containing .01% to 1% boron mononitride, .03% to 1.5% carbon, 4% to 18% chromium, 0 to 3% silicon, 0 to 2% manganese, the remainder being iron except for incidental impurities.

14. A martensitic stainless steel according to claim 13 including 0 to 2.5% nickel.

15. A martensitic stainless steel according to claim 13 or 14 including at least one of the elements molybdenum, zirconium, phosphorus, sulphur, selenium, lead, tellurium, arsenic and bismuth in an amount conventional for promoting easy machinability.

16. A high temperature, heat resistant alloy having improved machinability produced by the process according to any one of claims 1 to 4 and containing .01% to 1% boron mononitride, 0 to .3% carbon, 0 to 3% manganese, 0 to 2% silicon, 0 to 30% chromium, the remainder being at least one of the elements iron, nickel or cobalt except for incidental impurities.

17. A high temperature heat resistant alloy according to claim 16 including 0 to 15% molybdenum and/or tungsten, 0 to 10% columbium, 0 to 10% titanium and 0 to 10% aluminum, the combined total of titanium and aluminum being not more than 15%.

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